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(71) Applicant
Uniroyal Englebert Reifen GmbH

(Incorporated in the Federal Republic of Germany)

Postfach 410, Hüttenstrasse 7, 5100 Aachen 1,
Federal Republic of Germany

(72) Inventor
Dionysius Poque

(74) Agent and/or Address for Service
Potts Kerr and Co
15 Hamilton Square, Birkenhead, Merseyside, L41 6BR,
United Kingdom

(54) **Tyre tread pattern**

(57) A pneumatic vehicle tyre has tread surface profile elements 4_1 to 4_{17} which have grooves of different lengths. These grooves may be combined with fine grooves (9) (Figs 4, 5, 7). As a result of such grooves being distributed irregularly, the vibration frequencies of the profile elements are split into a broad frequency spectrum, so that the noise level produced by the tyre is substantially reduced. The profile elements may be at angles of 45° to 90° with respect to the central plane of the tyre.

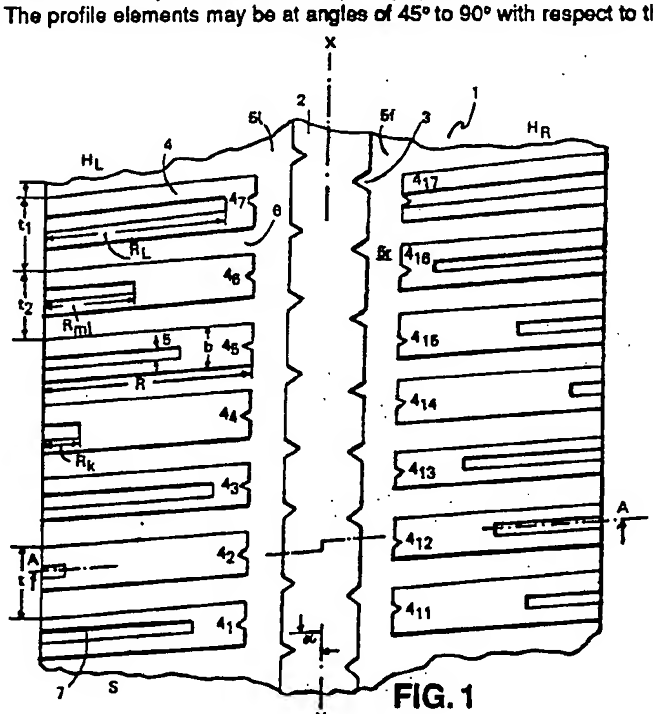


FIG. 1

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

GB 2 242 171 A

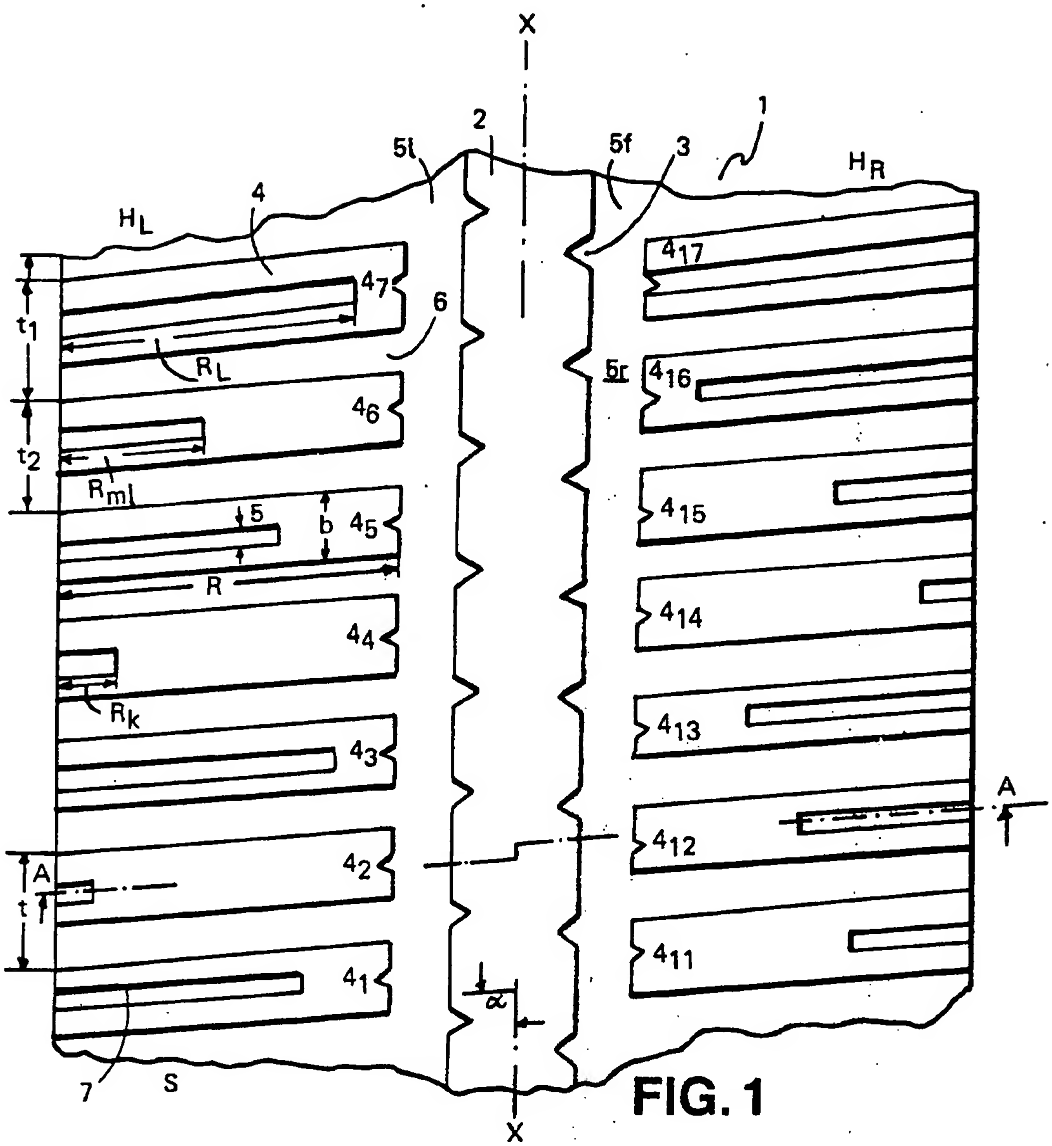

X
2
1
5l
5f
3
H_R
H_L
4
4_7
4_{17}
6
t_1
R_L
5r
4_{16}
4_6
t_2
R_{ml}
5
b
4_5
4_{15}
R
4_{14}
4_4
R_k
4_{13}
4_3
A
4_{12}
4_2
A
t
4_{11}
4_1
α
7
S
X

FIG. 1

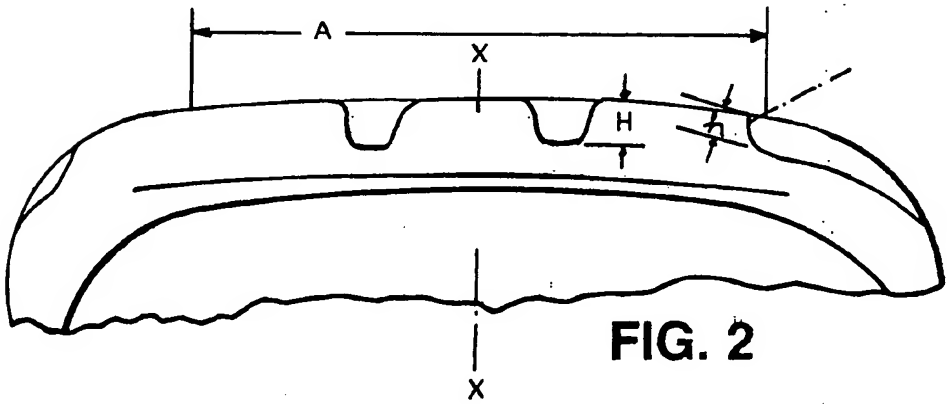

A
X
H
h
X

FIG. 2

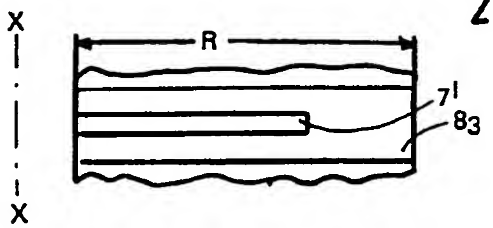


FIG. 3

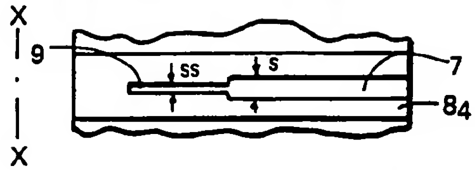


FIG. 4

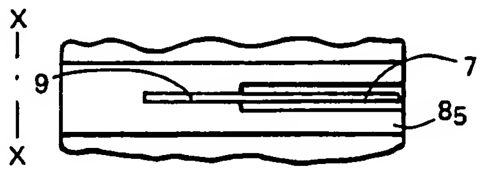


FIG. 5

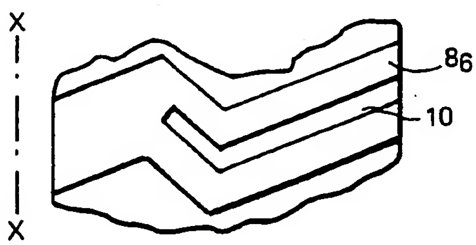


FIG. 6

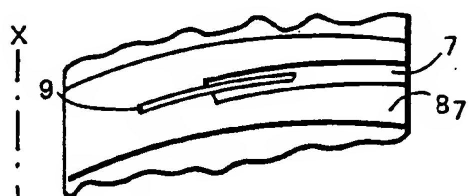


FIG. 7

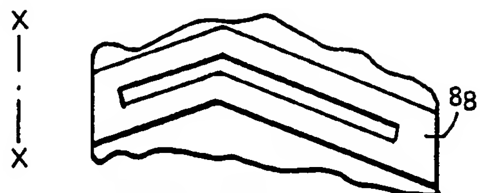
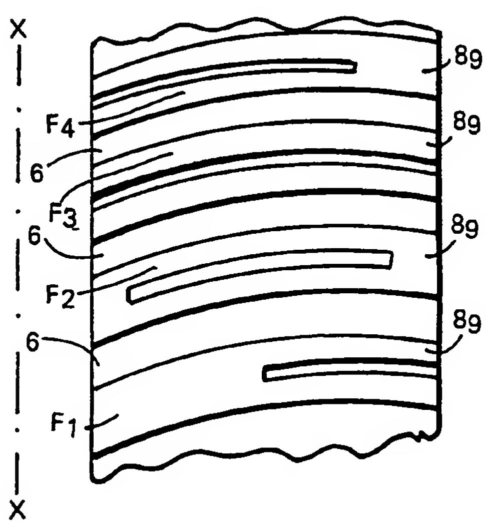


FIG. 8

FIG. 9



PNEUMATIC VEHICLE TYRE

The invention relates to a pneumatic vehicle tyre of radial construction, having a radial carcase and a belt-reinforced, profiled tread strip, wherein the tread surface profile comprises profile elements, which are separated from one another by means of grooves. The profile elements are disposed at an angle of orientation α of from 45° to 90° relative to the central plane of the tyre, and they are disposed at predetermined, but selectable, circumferential spacings. The profile elements each have at least one groove, the longitudinal edges of which extend substantially parallel with the longitudinal edges of the profile elements.

Profile elements are also disposed in the tread surface according to circumferential spacing measures for the purpose of reducing tyre noise. As it rolls along a contact surface, e.g. a road, a pneumatic vehicle tyre produces a more or less clearly audible noise. On the one hand, it is produced as a result of an impact noise when the edge of the profile element strikes against a contact surface and, on the other hand, it is caused by vibrations which are produced when the profile edge of a profile element leaves the contact surface again.

In addition, noises occur which are caused by vibrations of the profile elements on the carcase, which is tensioned like a diaphragm, and result from excited air columns in the grooves of the tyre profile.

The outgoing noise of the profile element is generally greater than the incoming noise. The

vibration frequency differs between these two sources of noise.

In order to reduce the noise level of a pneumatic vehicle tyre generally, it is known to widen the noise frequency band by means of predetermined, but selectable, circumferential spacing sequences, whereby the uniformity is purposefully disturbed by sequence lengths of different sizes. Circumferential spacing measures are described, for example, in DE-A-29 05 051 and 36 09 488.

An object of the invention is to further improve the noise level for pneumatic vehicle tyres of the initially described type.

The object of the invention resides in disposing and providing the grooves in the profile elements, so that additional vibration resonances are produced, whereby the total noise level of the tyre is further reduced.

According to the invention, this is achieved in that the grooves in the profile elements, which are disposed in accordance with circumferential spacing, have different lengths, and in that grooves of different lengths are distributed irregularly, when viewed over the circumference, but they are dependent on the sequence of the circumferential spacings.

In such case, the longest groove length R_L may be 1.0 of the block length R, and the shortest groove length R_K may be 0.1 of the block length R, measured from one of the two end edges of the block provided. The groove has an incision-like configuration.

Groove lengths of substantially 0.3 to 0.5 of the length of the profile elements are preferred.

In addition to the difference in circumferential spacing, grooves of such different lengths in the profile elements introduce a conscious interference, which is irregular over a circumferential portion, into the excitation and vibration resonance of the tread surface profile at the respective location of a profile element of the shoulder. This interference may be provided in the form of alternately long and short grooves, it may be provided by pairs of alternately long and short grooves, or be provided by long and short grooves which are partially rectilinear and partially angled, but it may also be provided by short grooves over a partial region according to circumferential spacing and subsequently by grooves of different lengths in sequence.

The groove involved here has a groove depth of 1/5 to 4/5 of the normal profile depth. The width of the groove is variable and may be 0.2 to 2.5 times the groove depth.

As a result of grooves being so disposed and provided in the profile elements of the shoulder region, on the one hand, the vibration frequency, which is inherent in the profile element of the shoulder, is changed and, on the other hand, the excitation frequency of the profile element is appropriately influenced in the contact surface.

This measure reduces the amplitude of the inherent resonance of the tyre support at each location where a profile element is situated and, in consequence, the total rolling noise of the tyre

profile is reduced to a relatively low noise level. It is desirable for a soft, quiet noise to be generally achieved for the rolling noise.

In addition, the groove in the profile element may be combined with a fine groove, which is known per se and is also called a segment. The fine groove may communicate with the groove and/or it may extend into same, the fine groove then being provided in the groove base. As a result of these further measures, the vibration frequencies of the profile elements are further modified and, in addition, influence the excitation intensity of the vibrations in the respective contact surface.

The grooves in the profile elements with rectilinear boundary edges likewise extend in a rectilinear manner and parallel with these edges. The grooves in the profile elements with angled boundary edges extend partially in a rectilinear manner and parallel and at least parallel with one of these boundary edges. In profile elements with curved boundary edges, the grooves are also substantially curved and extend parallel with the boundary edges of the profile element.

The present invention will be further, illustrated, by way of example, with reference to the accompanying drawings, in which:

Fig. 1 illustrates a tread surface profile (cutaway portion) with profile elements of the shoulder, which have partially longer and partially shorter grooves;

Fig. 2 is a cross-sectional view taken along the line A to A of Fig. 1;

Fig. 3 shows a detail of a profile element of

the shoulder, having a groove-like incision which has its opening on the side facing the centre of the tyre;

Fig. 4 shows a detail of a profile element of the shoulder, having a groove-like incision which has its opening on the shoulder side, and wherein a fine groove extends towards the centre of the tyre;

Fig. 5 shows a detail of a profile element of the shoulder, having a groove-like incision and a modified fine groove;

Fig. 6 shows a detail of an angular profile element of the shoulder, having a groove-like, bent incision;

Fig. 7 shows a detail of a curved profile element of the shoulder, having a likewise curved, groove-like incision and a combined fine groove;

Fig. 8 shows a detail of a further profile element of the shoulder, having a modified disposition and configuration for the incision; and

Fig. 9 illustrates a group of profile elements of the shoulder, which are distributed over the circumference and each have incisions of different lengths.

The tread surface profile 1 of Fig. 1, which is shown as a cutaway portion, substantially comprises a central circumferential rib 2, which has lateral recesses 3, which serve to influence the noise, and a plurality of profile elements 4, which are disposed in the shoulder regions and are shown as rectangular blocks for the purpose of simplified representation and explanation. These profile elements each form a tread surface half H_L, H_R on either side of the central plane x - x of the tyre. These profile elements are separated from the central rib 2 by means of circumferential grooves 5_l and 5_r and extend inclinedly relative to the central plane x - x at an angle α from

the central region of the tread surface into the shoulder region S. The angular disposition may be 45° to 90°.

Instead of a rib, a plurality of circumferential ribs or one or a plurality of rows of blocks may be provided.

In each tread surface half, the profile elements are disposed in the circumferential direction with a spacing from one another and are defined by a respective transverse groove 6. The profile elements are disposed at predetermined, but selectable circumferential spacings t, the spacings t_1 and t_2 being able to be different from one profile element to the other. Furthermore, the widths b of the profile elements are different. As a result of such a basic disposition of the profile elements, a noise frequency band is already formed which, because of the different spacing lengths t, reduces the frequency level when compared with that produced with profile elements which have identical spacing lengths.

In order to spread-out the sound energies of the profile, which are produced with a rolling pneumatic vehicle tyre, over a wide frequency band, the groove-like incisions provided in the profile elements, more especially in the shoulder regions, are additionally given different lengths.

The tread surface profile 1 shows this in simplified form by means of partially long, partially medium-length and partially short grooves 7, the long groove being referenced R_L, the medium-length groove being referenced R_{m1}, and the short groove being referenced R_K. Such profile element grooves of

different lengths additionally interfere with the vibration resonances achieved by the different circumferential spacings. Because of the grooves, the amplitudes of the inherent resonances of the profile elements are changed and appropriately divided into frequencies with a low and relatively high frequency range in the profile elements according to the circumferential spacing. The amplitudes of the inherent resonances of the support, bearing the profile elements, are likewise changed thereby. Long grooves have a groove length of 1.0 or 0.9 of the lengths of the profile element, and short grooves have a length of 0.1 of the length of the profile element, and the lengths of the grooves in between are variable between the two above-mentioned limit values.

The profile elements, which are provided in the circumferential direction in respective transverse rows, have, for example, a groove 7 with a groove length of 75% of the profile element length in the left-hand profile half H_L in the profile element 4_1. The block 4_2, which follows in the circumferential direction, has a short groove with a length of 15% of the profile element length. This block has no groove in the contact surface with the contact width A, cf. in this connection, the cross-sectional view of Fig. 2, so that the short groove length is only effective in the shoulder region. The block 4_3, which is situated further in the circumferential direction, has a groove with the length R_L of 85%, and the block 4_4, which follows further, has a groove length of 17%. The block 4_5, which follows further, has a groove length R_{ml} of 65%, and the block 4_6, which follows further, has a groove length of 45%, and the block 4_7, which follows further, has a groove length of 85%.

The profile elements, which are provided in the circumferential direction in transverse rows, have profile elements 4_{11} to 4_{17} with comparable grooves 7 in the right-hand profile half H_R, but such profile elements have different groove lengths from the profile elements which are disposed opposite them.

By detecting the amplitude with fixed spacing lengths, the disposition and configuration of the grooves can be so determined that a wide frequency band of low frequencies is obtained with the purpose of achieving only a slightly perceptible sound in the rolling noise.

Further measures are shown in Figs. 3 to 9 and explained. According to Fig. 3, a profile element 8_3 is provided with a groove 7', the opening of which is situated on the side x - x at the centre of the tyre, and said groove extends in the direction of the shoulder S, but terminates blind before the end of the profile element. According to Fig. 4, the profile element 8_4 has a groove 7, which has its opening situated on the side of the shoulder and terminates blind in the centre of the profile element, but it has an additional groove here in the form of a fine groove 9, which is known per se. The groove 7 is hereby extended as a groove with a width s and is subsequently extended by a narrower fine groove, with a smaller cross-section and with the width ss, and, in this respect, it constitutes an interference location having two different frequencies.

The grooves are preferably approximately half as deep as the normal profile depth between the profile elements in the main circumferential and transverse grooves or, however, they are adapted to decrease

slightly to 1/5 of the profile depth from the centre of the tyre to the shoulder of the tyre. The width s of the groove may be 0.1 of this groove depth and may vary up to 300%, so that a wide groove of up to 2.5 of the groove depth may also be provided according to the width of the profile element. Preferred widths are between 1.5 and 4 mm.

Fig. 5 shows a modified form of a groove and a fine groove. The opening of the fine groove is situated on the side of the shoulder and terminates blind in the profile element. The fine groove, which is additionally provided, is situated in the base of the fine groove and extends over its finite length further into the profile element.

Fig. 6 shows an angular profile element 8_6, the groove 10 of which likewise has an angular configuration. However, the groove may terminate in the region of the bend location.

Fig. 7 shows a profile element 8_7, which has a fine groove commencing in the centre of the groove and terminating in the profile element.

The fine groove is provided partially in the base of the groove and extends further into the profile element and also terminates blind here.

Fig. 8 shows a profile element 8_8, which has an angular configuration, and wherein the groove is likewise angular.

Fig. 9 illustrates a group of curved profile elements 8_9, which have different groove lengths in the respective profile element. For example, the groove in

the lower profile element extends substantially to the location where the tyre contact surface is situated. In consequence, the surface F_1 is free of any groove edge. In the further profile element, the contact surface F_2 is provided with additional edges from the groove which is situated there and is centrally disposed. In the further profile element, the surface F_3 is totally divided by a groove, which extends over the entire length of the profile element. In the profile element, which follows further, the surface F_4 in the contact surface is likewise divided by the edges of the groove. These four different grooves produce different inherent frequencies and, when viewed together, form a portion of a noise frequency band with inherent frequencies which succeed one another briefly and have frequency peaks which are low.

Because of the above-described grooves of different lengths and/or fine grooves which are disposed in combination, a predetermined frequency range in the frequency band may be appropriately produced in each profile element, and the profile noise may be influenced in this manner.

CLAIMS

1. A pneumatic vehicle tyre of radial construction, having a radial carcase and a belt-reinforced, profiled tread strip, wherein the tread surface profile comprises profile elements, which are separated from one another by means of longitudinal and transverse or inclined grooves, said profile elements in the tread surface region being disposed at an angle of orientation α of from 45^{o} to 90^{o} relative to the central plane of the tyre and being provided at predetermined, but selectable, circumferential spacings and wherein the profile elements each have at least one groove, in which the grooves in the profile elements, which are disposed in accordance with said circumferential spacing, have different lengths, and grooves of different lengths are distributed irregularly over the circumference, the longest groove length being 1.0 times and the shortest groove length being 0.1 times the profile element length, measured from one of the two end edges of the profile elements, and in which the grooves have an incision-like configuration.

2. A pneumatic vehicle tyre as claimed in claim 1, in which the groove has a depth of 4/5 to 1/5 of the profile depth and a width of 0.2 to 2.5 times as depth.

3. A pneumatic vehicle tyre as claimed in claim 1 or 2, in which the groove is combined with a fine groove, the fine groove being adapted and disposed so as to communicate with the groove and/or extending into said groove, the fine groove then being provided in the groove base.

4. A pneumatic vehicle tyre as claimed in claim 1, 2 or 3, in which the grooves in the profile elements of the shoulder region with rectilinear boundary edges extend in a rectilinear manner and parallel with these edges, and, in the profile elements with angled boundary edges, they extend in a rectilinear manner and parallel but at least parallel to one of the boundary edges, and, in the profile elementswith curved profile edges, they extend in a substantially curved manner and parallel with these edges.

5. A pneumatic vehicle tyre, substantially as hereinbefore described with reference to the accompanying drawings.

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